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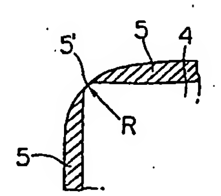
(54) Cutting tool and the production thereof and use of the same.

(57) A cutting insert having excellent toughness as well as wear resistance is provided comprising a substrate (4) consisting of a sintered hard metal or alloy, such as a cemented carbide, and a coating film (5) provided thereon consisting of a material having a greater hardness than the substrate (4), the coating film (5) near the cutting edge (5') being thinned or removed towards both the rake face and the flank face.

FIG. 5
(b)



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CUTTING TOOL AND THE PRODUCTION THEREOF AND USE OF THE SAME

This invention relates to coated hard metal tools suitable for use in the cutting of metals, for example, turning, milling, threading, drilling or boring, and a process for producing the same. The coated hard metal used herein usually comprises a substrate of a cemented carbide consisting of e.g. WC, TiC or TaC and an iron group metal or a substrate of hard sintered alloy such as cermet consisting predominantly or e.g. TiC or TiN and a coating layer provided thereon consisting of a carbide, nitride, carboxide, carbonitride, oxide or solid solution thereof of a Group IVa, Va or VIa element of the Periodic Table, Al, Zr or the like, the coating layer having a higher hardness and wear resistance than the substrate.

In the field of cutting metals, working conditions have become severer with the years and it has been required for cutting tools used to this end to have increased hardness, wear resistance and heat resistance. Cemented carbide tools are capable of satisfying these

requirements to some extent, but the use of tools of cemented carbides with various hard coating layers has lately been spreading. A typical form of such a tool is shown in Fig. 1 in which a square insert is fixed to a holder. This is generally called a throwaway insert which is to be thrown away to permit an exchange for a new insert after using the eight cutting edge corners. In these coated cemented carbide tools, the surface of the cemented carbide tip 4 is ordinarily coated by the CVD method, PVD method or the like. Fig. 1(b) is a cross-sectional view of insert 1 along line A-A and Fig. 2 and Fig. 3 are enlarged views of cutting edges 2 near dotted line B. As shown in these figures, the coated cemented carbide inserts of the prior art each have a thicker part near the cutting edge 2 than at other parts, which differs somewhat depending upon the shape of the cutting edge. When the coating film is of Al_2O_3, in particular, that part is usually thicker. In general, if the coating film is thicker, the wear resistance is increased, but the toughness is lowered and chipping tends to occur. That is, inserts having a coating layer near the cutting edge as shown in Fig. 2 and Fig. 3 meet with the drawback that deterioration of the finished surface of a workpiece is caused by the disorder of wearing due to a lowering in the toughness, breakage of

the cutting edge and micro-chipping.

Various proposals have been made so as to overcome the above drawback. Thus, for example, Japanese Patent Publication No. 37553/1973 describes a method for making a cemented carbide cutting tool comprising forming a coating layer consisting predominantly of TiC on the whole surface of a cemented carbide insert and removing by grinding the coating layer on the land between the cutting edge and a groove for chip breaking,retaining the coating layer on only the groove for chip breaking. However, this method has not been put to practical use yet, because it cannot be applied to inserts without a chip breaker and inserts with a bumpy chip breaker, and it encounters problems that the cutting edge is unfavourably affected by chips occurring by grinding and cutting edges 5' and 7' shown in Fig. 4 are brittle due to the sharpness caused by grinding only the rake face. These problems similarly cannot be solved by a similar method which is described in Japanese Patent Application No. 92732/1971.

In the prior art, therefore, the strength of an edge can be increased to some extent, but resistance is not improved.

According to the invention, a cutting tool comprises a susbtrate consisting of a sintered hard metal or alloy

such as a cemented carbide and a coating film provided thereon consisting of a material of greater hardness than the substrate, in which the coating film near the cutting edge is thinned or removed towards both the rake face and the flank face.

The present invention thus enables the provision of a coated cemented carbide cutter for turning, milling, threading, drilling and boring machines.

It is a still further aspect of the present invention to provide a process for producing a coated cemented carbide cutting tool with excellent stability and long life by controlling the thickness of the coating film at the cutting edge part of the coated cemented carbide tool.

The accompanying drawings serve to illustrate the principle and merits of the present invention in more detail.

Fig. 1(a) is a perspective view of a throwaway insert of cemented carbide in general form and Fig. 1(b) is a cross-sectional view along line A-A of Fig. 1(a).

Fig. 2 to Fig. 3 are enlarged cross-sectional views of part B in Fig. 1(b) showing various coated cemented carbide inserts of the prior art.

Fig. 4(a) and (b) are enlarged cross-sectional views near the cutting edges of coated cemented carbide inserts

subjected to edge working according to the prior art.

Fig. 5 and Fig. 6 are enlarged cross-sectional views near the cutting edge of coated cemented carbide inserts of the present invention.

Fig. 7 shows a cross-sectional view of a workpiece used for testing an insert of the present invention, and shows the position of the insert.

The feature of the present invention resides in the coating film near the cutting edge of a coated hard metal cutting tool of the prior art being thinned or removed towards rake face side C and flank face side D, whereby not only edge strength but also wear resistance is improved.

In the present invention, the hard metal preferably comprises at least one carbide, optionally with at least one nitride, of Group IVa, Va and VIa elements of the Periodic Table and a metal binder selected from the iron group metals, and has at least one coating layer having a greater hardness than the hard metal and preferably consisting of at least one of the carbides, nitrides, carboxides, carbonitrides and oxides of Group IVa, Va and VIa elements of the Periodic Table and Al, and solid solutions thereof.

In the tool of the present invention not only is the toughness markedly improved, but also the wear

resistance is raised unexpectedly compared to the prior art, while in the prior art method wherein the coating film on only rake face C is removed, only toughness is somewhat improved. The meritorious effect of the present invention is remarkable when the minimum value t of the film thickness near the cutting edge is at most 60% as shown in Fig. 6(a) and considerable even in the case of at most 90%, and it can be maintained when substrate 4 is partly exposed as shown in Fig. 6(b) and (c). Furthermore, the effect of the present invention is particularly remarkable when the coating film is maximized near the cutting edge as shown in Fig. 3. In Fig. 3, inner layer 6 consists generally of at least one hard material selected from carbides, nitrides, oxides and solid solutions thereof of metals such as Ti and has substantially a uniform thickness, and outer layer 7 is a layer consisting predominantly of an oxide or oxynitride of Al or Zr which tends to be maximized in film thickness near the cutting edge. In a cutting tool having a multilayer coating of an oxide or oxynitride of Al or Zr and a hard compound of Ti in combination, therefore, it is preferred to thin the maximized film thickness near the cutting edge or to remove the coating layer to expose the substrate according to the present invention.

Fig. 5(a) to (c) and Fig. 6(a) to (c) are enlarged cross-sectional views of throwaway inserts near the cutting edges as embodiments of the coated cemented carbide cutting tool according to the present invention. Referring to Fig. 5(a), the cutting edge of substrate 4 non-treated is coated as shown in Fig. 2(a) and coating film 5 is removed at an angle of θ in such a manner that the film thickness is gradually increased from the exposed part of substrate 4 towards both the rake face and the flank face. Referring to Fig. 5(b), the cutting edge of substrate 4 is coated as shown by R in Fig. 2(c) and then subjected to a honing treatment to make coating film 5 thinner near cutting edge 5'. Fig. 5(c) is an example wherein the coating film is removed to expose substrate 4'.

Referring to Fig. 6, the cutting edge of substrate 4 is subjected to rounded honing in such a manner that the rake face is more worked than is the flank as shown in Fig. 2(d), after which hard coating film 5 is formed and then subjected to working using an elastic grindstone, thus obtaining cutting inserts of the present invention. Fig. 6(a) shows an example wherein a coating film with a thickness of t is retained near the cutting edge to satisfy the relationship of $t<T$ for the maximum coating thickness T. $(t/T) \times 100$ is preferably at most 90, more

preferably at most 60. Fig. 6(b) and (c) are examples wherein t = 0 and substrate 4' is exposed, and in the case of (b), the edge is made round before coating, while in the case of (c) a sharp edge is held before coating.

In Fig. 5(a), working is carried out by chamfer-honing, but a barrel treatment after coating is preferred. Furthermore, it is more preferred in view of the lowered yield due to breakage of the cutting edge and operational efficiency to arrange a number of coated inserts on a rotary disk in such a manner that the rake faces are thereabove, and to push an elastic grindstone containing grinding grains such as SiC, e.g. a buff or brush consisting of a resin with grinding grains, revolving against the edge parts of the inserts from the rake face, thus lapping simultaneously the rake face and flank face and smoothly thinning the film on and near the cutting edge. According to this method, the film on the side of the rake face is made thinner than on the side of the flank face, the sides being separated by the cutting edge as a boundary, so wear resistance can be held by the film thickness of the flank side and toughness can be held by the thinner film on the rake side. The resulting cutting insert exhibits a particularly excellent performance.

The following Examples are given in order to ....

illustrate the present invention in detail without limiting the same.

Examples

Various cemented carbide inserts having a Form No. of ISO and SNMA 120408 were coated with various hard coating films shown in Table 1. Edge treatments before coating the cemented carbide inserts were carried out as follows:

(i) No edge treatment as shown in Fig. 2(a)

(ii) Edge treatment of R = 0.05 as shown in Fig. 2(c)

(iii) Edge treatment to give a substrate of a = 0.03 mm and b = 0.06 mm as shown in Fig. 6(a).

Edge treatments after coating were carried out as follows:

(I) No edge treatment

(II) Edge treatment by chamfering to give $\theta = 20°$ and C = 0.09 mm in Fig. 5(a)

(III) Edge treatment by barrel polishing to give $t<T$

(IV) Edge treatment by lapping with an elastic grindstone to give $t<T$.

(V) Edge treatment by lapping with a brush to give $t<T$

The above described various coated cemented carbide inserts were subjected to tests for toughness and wear resistance and the results are shown in Table 2 with Coating Film Thickness Ratio after coating, (t/T) x 100. The test conditions are as follows:

Test Conditions of Toughness

Workpiece: round rod with four grooves of SCM 435 (Hs 36) as shown in Fig. 7

Holder: PSBNR 2525-43

Cutting Speed: 80 m/min

Cutting Depth: 2 mm

Feed: 0.12 - 0.28 mm/rev (sam material group: under same condition)

Assessment: number of impacts till breakage (average value of eight tests)

Test Conditions of Wear Resistance

Workpiece: round rod of SCM 415 (Hs 26)

Holder: PSBNR 2525-43

Cutting Speed: 230 m/min

Cutting Depth: 2 mm

Feed: 0.3 mm/rev

Time: 15 min

Assessment: measurement of flank wear width (mm)

TABLE 1

No.	Coating Film (Film Thickness: value on plane part)	Substrate
E	Titanium Carbide (8 µm) Single Layer	ISO P 30 (Cemented Carbide)
F	Titanium Nitride (1 µm)/Titanium Carbonitride (3 µm)/Titanium Carbide (4 µm) 3 Layers	ISO P 30 (Cemented Carbide)
G	Titantium Oxynitride (1 µm)/Alumina (1.5 µm)/Titanium Carbide (5.5 µm) 3 Layers	ISO M 20 (Cemented Carbide)
H	Titanium Nitride (3 µm) Single Layer	ISO P 10 (Nitride-containing Cermet)
I	Zirconia (0.5 µm)/Aluminium Oxynitride (1 µm)/Titanium Carbide (6 µm)	ISO M 20 (Cemented Carbide)
J	Alumina (1 µm)/Hafnium Nitride (1 µm)/ Titanium Carbide (1 µm) 3 Layers	ISO M 20 (Cemented Carbide)

TABLE 2

No.	Material	Treatment Before Coating	Treatment After Coating	Film Thickness Ratio (t/T) x 100	Toughness Test number of impact	Wear Resistance Test flank wear (mm)
1	E	ii	I	105	62	0.43
(2)		i	II	0	175	0.34
(3)		ii	III	70	193	0.28
(4)		ii	IV	95	86	0.41
(5)		ii	IV	90	186	0.36
(6)		ii	IV	60	483	0.29
(7)		ii	V	40	539	0.28
(8)		i	IV	0	782	0.23
9	F	ii	I	110	55	0.41
(10)		i	II	0	180	0.33
(11)		ii	III	70	168	0.29
(12)		ii	III	60	406	0.27
(13)		ii	IV	95	64	0.40
(14)		ii	IV	55	149	0.24
(15)		ii	IV	0	444	0.23
(16)		i	V	0	724	0.21
17	G	iii	I	140	33	0.35
(18)		i	II	0	229	0.29
(19)		iii	III	50	233	0.25
(20)		iii	IV	50	402	0.20
(21)		i	IV	0	413	0.20
22	H	ii	I	105	6	broken
(23)		i	II	0	150	0.22
(24)		ii	III	0	175	0.16
(25)		i	IV	0	207	0.13
26	I	ii	I	155	67	0.46
(27)		ii	IV	80	289	0.38
(28)		ii	IV	60	374	0.30
(29)		i	IV	0	412	0.27
30	J	iii	I	145	91	0.49
31		iii	IV	100	138	0.47
(32)		iii	IV	0	351	0.33
(33)		i	IV	0	548	0.32

As is evident from Table 2, the inserts of the present invention indicated by Nos. in parentheses exhibit excellent toughness as well as excellent wear resistance.

CLAIMS:

1. A cutting tool having a cutting edge and including a substrate comprising a sintered hard metal or alloy and a coating film provided thereon comprising a material of greater hardness than the substrate, the coating film near the cutting edge being thinned or removed towards the rake face and the flank face.

2. A tool as claimed in claim 1, wherein the coating film near the cutting edge is thinned continuously in both the rake face direction and the flank face direction.

3. A tool as claimed in claim 1, wherein the coating film near the cutting edge is smoothly removed in both the rake face direction and the flank face direction.

4. A tool as claimed in claim 1, wherein the width of the coating film thinned or removed is larger at the rake side than at the flank side.

5. A tool as claimed in any one of claims 1 to 4, wherein the sintered hard metal or alloy comprises at least one carbide, optionally with at least one nitride, of Group IVa, Va and VIa elements of the Periodic Table and optionally a metal binder selected from the iron group metals.

6. A tool as claimed in any one of claims 1 to 5,

wherein the material of greater hardness comprises at least one of the carbides, nitrides, carboxides, carbonitrides or oxides of Group IVa, Va and VIa elements of the Periodic Table and aluminium, and solid solutions thereof.

7. A tool as claimed in any one of claims 1 to 6, wherein the coating film comprises at least two layers, at least one of which consists predominantly of at least one of the oxides and oxynitrides of aluminium and zirconium.

8. A tool as claimed in claim 1, wherein the coating film is formed by a CVD method or PVD method.

9. A process for the production of a cutting tool comprising subjecting a substrate consisting of a sintered hard metal or alloy to a coating treatment to provide a coating film thereon consisting of a material of greater hardness than the substrate and to a honing treatment in such a manner that the resulting coating film near the cutting edge is thinned or removed, preferably continuously, towards both the rake face and the flank face.

10. A process as claimed in claim 9, wherein the honing treatment is carried out by arranging a number of the coated substrates on a rotary disk in such a manner that the rake faces are thereabove and

contacting revolving flexible grinding means against the edge parts of the coated substrates from the rake face thereby lapping simultaneously the rake face and flank face with a greater width of the coating film thinned or removed at the rake side than at the flank side.

11. A process as claimed in claim 10, wherein the grinding means is a buff or brush comprising a resin with grinding grains.

12. A method of cutting a metal which comprises subjecting the metal to the cutting action of a tool as claimed in any one of claims 1 to 8.

FIG. 1

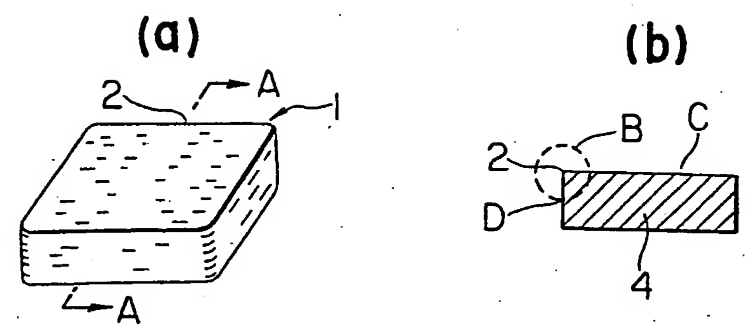
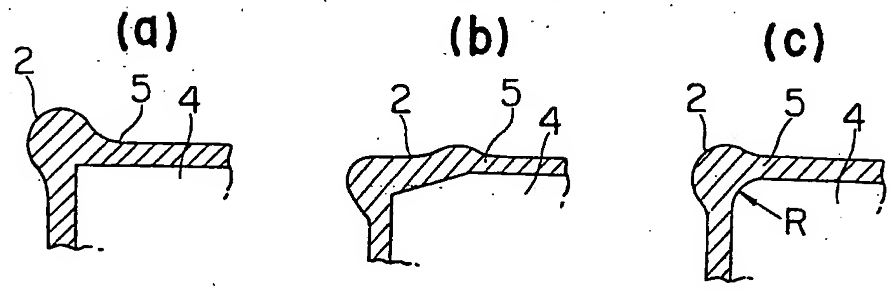


FIG. 2



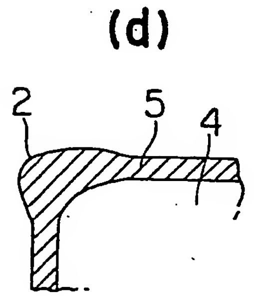


FIG. 3

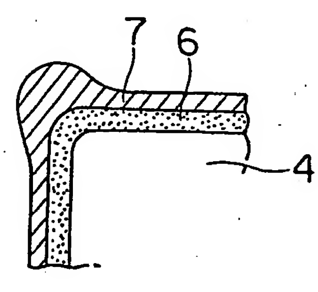


FIG. 4

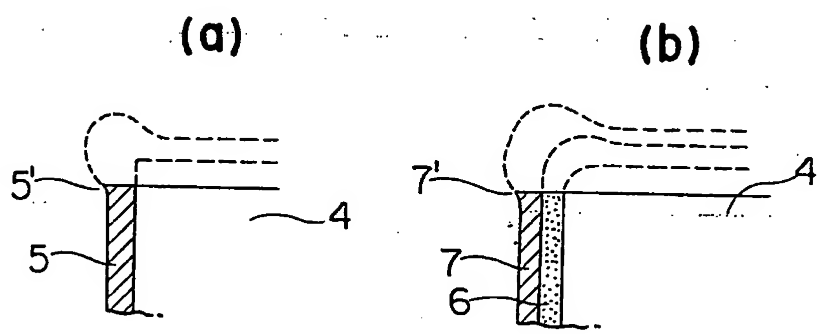


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FIG. 5

(a) (b) (c)

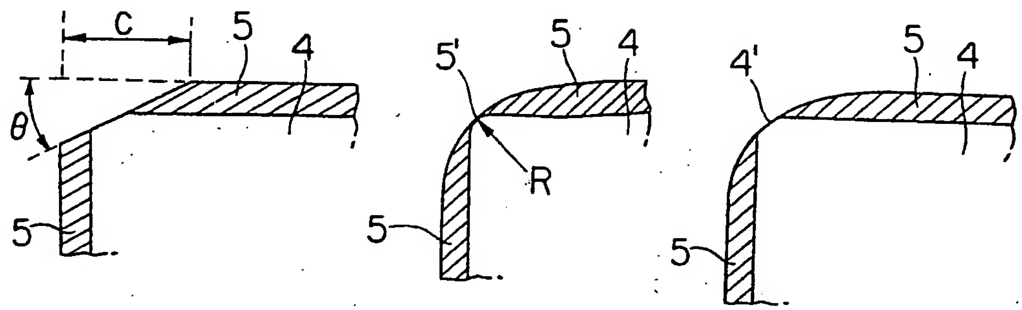
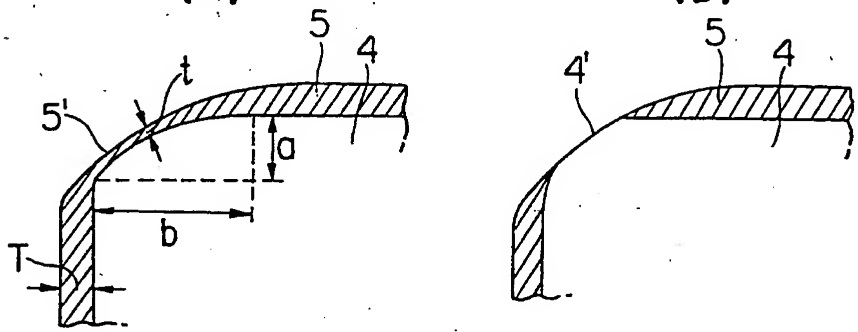


FIG. 6

(a) (b)



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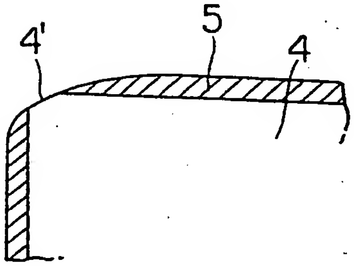

FIG. 7